Technical Note 6-77

DEVELOPMENT OF PRELIMINARY SIZING CRITERIA FOR IMPROVED GOGGLES; SUN, WIND AND DUST

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June 1977

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U. S. ARMY HUMAN ENGINEERING LABORATORY
Aberdeen Proving Ground, Maryland

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Technical Note 6-77	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) DEVELOPMENT OF PRELIMINARY SIZING CRITERIA FOR IMPROVED GOGGLES; SUN, WIND AND DUST		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) R. Bradley Randall		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Human Engineering Laboratory Aberdeen Proving Ground, Maryland 21005		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE June 1977 13. NUMBER OF PAGES 7
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Goggles
Sizing Criteria
Combat-Vehicle Crewmen
Goggles' Dimensions
Human Factors Engineering

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents design criteria for use by engineers and designers in the development of improved goggles for combat-vehicle crewmen. These criteria were derived from an analysis of relevant physical anthropometry and interfacing equipment dimensions, both of which impose limits on goggles' dimensions.

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AD-A041334

DEVELOPMENT OF PRELIMINARY SIZING CRITERIA FOR IMPROVED GOGGLES; SUN, WIND AND DUST

INTRODUCTION

The US Army is currently providing eye protection to combat-vehicle crewmen (CVC) by issuing Goggles; Sun, Wind and Dust, M-1944. One may correctly infer from the "M-1944" that this goggles' basic design is over 30 years old. These goggles were designed to interface with World War II vintage equipment. Although there have been minor changes through the decades, such as improved dustproofing, the basic design has endured. Today's soldier needs protection against today's hazards and needs goggles designed to work with today's equipment. This has been recognized and formalized in a Draft Letter of Agreement (LOA) dated 9 January 1976 (9). This LOA is to define design parameters and develop prototype hardware.

The need for improved protection against such hazards as low mass, low-velocity spall and blast debris became apparent during the Yom Kippur War. Of 207 eye-injury patients hospitalized in the Rambam Government Hospital in Haifa, Israel, over a 10-year period (1964-1973), 33 percent were for military injuries (7). This period included the armed conflicts known as the Six-Day War, The October War and the War of Attrition. The percentage of military injuries equaled that of industrial accidents. These injuries are only those which resulted in perforation of the eye by foreign material. Debilitating eye injuries to tank commanders or drivers during conflict could have disproportionate consequences should the tanks be in positions blocking the advance or withdrawal of other vehicles. In any case, such an injury to one man has often resulted in the entire tank crew being out of action. Goggles providing ballistic protection are a good means of reducing visual casualties.

In 1976 the Natick Research and Development Command (NARADCOM) initiated two programs to provide this needed protection. First, a Product-Improvement Program (PIP) was to supply improved lenses for retrofitting into existing goggles. This possibility was amply demonstrated by the US Army Human Engineering Laboratory (HEL) in April 1975 when a "quick-fix" for the M-1944 goggles was developed (6). A second, long-range program will lead to the development of completely new goggles which incorporate improved lenses. These new goggles are to provide protection primarily for the CVC, but could also be used by the drivers of other vehicles, artillerymen, skiers and others. HEL is responsible for providing human factors engineering expertise to insure the widest possible use and soldier acceptability of the new goggles.

METHOD

HEL's initial inputs to this development program are design criteria which NARADCOM engineers can use during the development of new goggles. Preliminary design criteria are to be used in the fabrication of goggles' mock-ups or prototypes which HEL will evaluate under actual or simulated conditions of use. These criteria may be refined, and the changes incorporated in a new series of prototypes to be subjected to further evaluation and refinement. Thus, the new goggles will evolve through a methodical, iterative process.

PROCEDURE

The first step in developing design criteria is to determine what constraining or forcing factors act to limit the dimensions of goggles. The first consideration must be user anthropometrics. These new goggles are to be close-fitting, which is especially important since one of the functions they perform is keeping dust and wind-blown debris out of the eyes. The facial dimension having the greatest impact on goggles' dimensions is the bicanthus or biocular. This measurement is the horizontal distance between the outer corners of the eyes. Goggles width obviously must be greater than the largest expected wearer's bicanthus measurement.

A second consideration is the equipment with which the wearer interfaces. CVCs wear helmets with integral communications equipment. They use optical fire-control equipment—gun sights and range finders—as well as vision blocks and periscopes.

Minimal outside dimensions will facilitate interfacing of the goggles with fire-control equipment. The "ideal" width lies somewhere between the largest expected bicanthus measurement and the most severely limiting browpad.

Approximately 40 percent of soldiers wear spectacles, which imposes yet another size constraint. Spectacles are issued in four frame sizes, the largest measuring 5.73 inches in width. Thus, the goggles must be at least this large to accommodate these soldiers.

Another limiting factor is the face-opening width of the smallest-size CVC helmet.

These four factors are the most significant determinants of goggles' size. Two—spectacles and bicanthus width—determine the minimum size; browpads and helmet face-openings restrict the maximum size.

Field of vision will be limited to some extent by goggles and this may affect job performance. This is an important factor but must be evaluated later in the program when prototype hardware is available.

Facial Anthropometrics

A literature search showed no current bicanthus data for male soldiers. A 1966 study of soldier anthropometry did not include this measure (10). The most recent survey which has bicanthus (or biocular) data was published in 1967 (4) and was done on 2,420 US Air Force flying personnel. The 99th percentile bicanthus width was 4.09 inches. An unpublished survey of 2,527 Air Force basic trainees in 1965 reported a 99th percentile value of 4.12 inches. The same value was reported for a 1500-man survey done on naval aviators in 1965 (3). A Chemical Warfare Service publication dated 1945 (2) presented a 99th percentile value of 3.95 inches. That survey included 3,075 men.

In January 1975 an anthropometric survey was conducted on 37 male soldiers who were on temporary duty at HEL. The 99th percentile bicanthus dimension was 4.07 inches.

The range for these sets of 99th percentile data covering a 30-year period was only 0.17 inches which indicates good stability. We can be reasonably certain that very few male soldiers will have a bicanthus dimension exceeding 4.12 inches.

Present doctrine precludes women from performing combat duty. In time of war however, circumstances could compel women to be in hostile fire zones, or subjected to other eye hazards against which goggles could be of value. A recently published (1972) and comprehensive source of anthropometric data on military females is a survey of air force women (1). Their 99th percentile biocular width is reported as 4.26 inches. Assuming the same degree of female bicanthus stability, it follows that goggles dimensioned for use by 99th percentile women should fit most male soldiers.

Fire-Control Equipment

The most restrictive browpad is a full-contact type which is a part of the M-50 and M-51 periscopes used on late-production M-60A1E2 tanks. This browpad has an opening width of only 4.06 inches at the level of a horizontal line through the pupils. The full browpad for the M-24IR and M-31 periscopes and M-17 range finder in M-60A1 tanks is 4.19 inches wide.

These browpads are restrictive to the point of not accommodating 99th percentile personnel of either sex.

CVC Helmets

The current "Standard A" helmet is model number DH-132, made by Gentex Corporation (8). This helmet consists of a flexible foam and mesh inner-liner available in three sizes. The smallest corresponds to a maximum hat size of 6 7/8. The medium inner-liner will fit sizes 7 to 7 1/4 and the largest is for sizes larger than 7 1/4. An outer shell is available in two sizes—large and medium. The medium shell is used for both small and medium inner-liners, while the large accommodates the large inner-liner. The most restrictive helmet combination is a medium shell on a small inner liner. This combination was fitted to a small-sized (# 1) headform of the 1945 Chemical Warfare Series and the minimum face-opening width measured. This helmet/head combination will accommodate seven-inch wide goggles.

A vertical dimension has also been included. The top of the lens should not be more than 1.00 inch above the center of a line through the wearer's pupils. This dimension was established to avoid interference with the CVC helmet.

The limiting dimensions are shown in Table 1.

TABLE 1

Dimensions Controlling Goggles Size
(Inches)

Size Limit	Factor	Size
Minimum Width	Spectacles	5.73
	Bicanthus	4.26
Maximum Width	Browpad	4.06
	CVC Helmet	7.00
Maximum Height	CVC Helmet	1.00 above pupils

DISCUSSION

It is apparent that the CVC helmet will accommodate goggles that are large enough to fit both spectacle wearers and 99th percentile bicanthus soldiers. Conflict arises between the need to accommodate both spectacles and browpads since the most restrictive browpad is narrower than the widest spectacles. From this conflicting requirement to accommodate both, it would seem that a minimum of two sizes of goggles are needed. The smaller for use with fire-control equipment; the larger for use with spectacles. Figure 1 shows the recommended dimensions on a representative goggles lens.

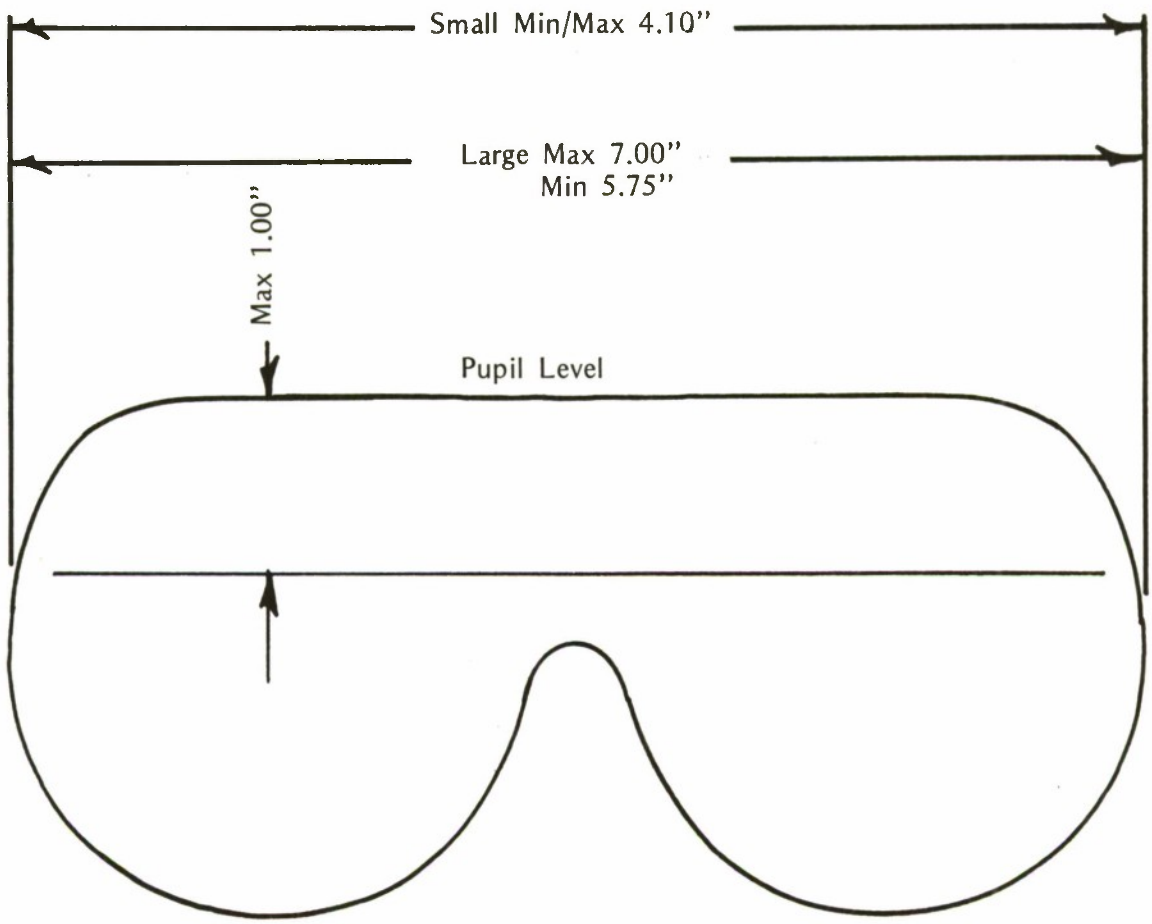


Figure 1. Recommended goggles dimensions.

Optical fire-control equipment is designed with sufficient diopter adjustment to accommodate users with deficient vision without their spectacles. These users could be issued goggles in the smaller size for use with such equipment, or small-sized goggles could be placed in the vehicle at the gunner's and commander's positions. Whether these individuals can perform the rest of their tasks without spectacles is a question best answered by an evaluation of selected operational tasks such as ranging, computer setting and using the radio and interphone.

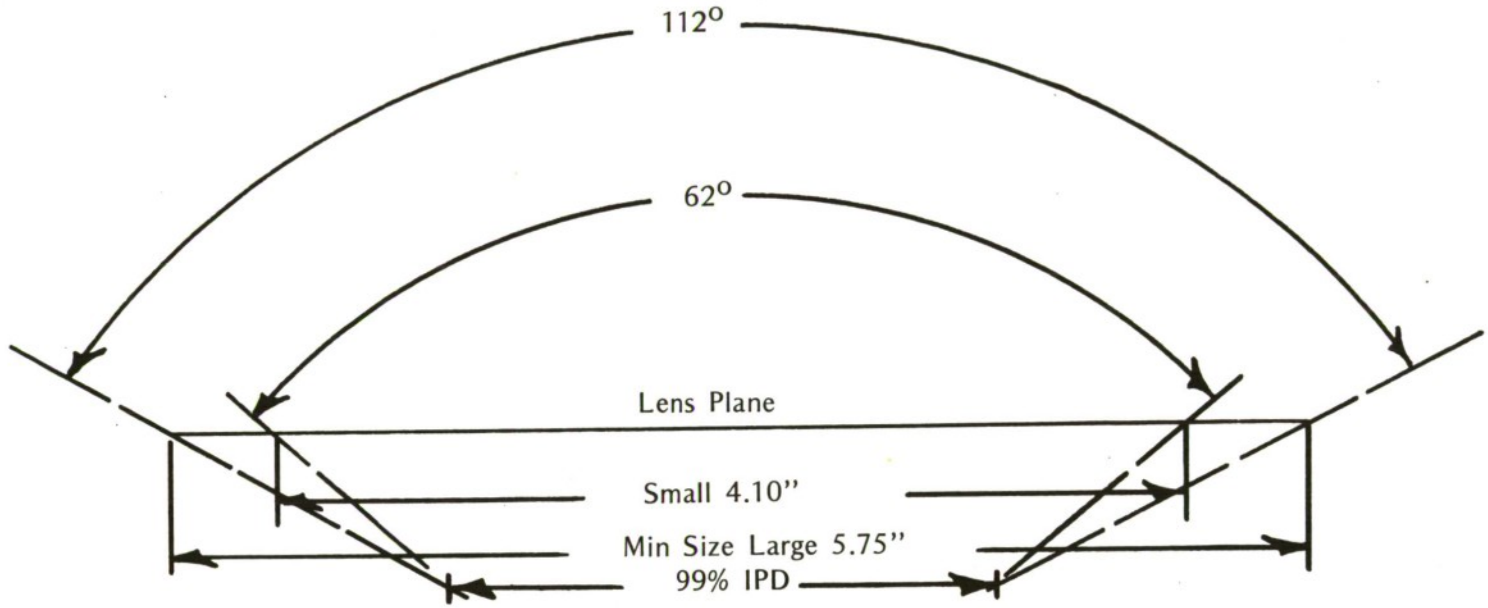
Horizontal field of view has been calculated for the two goggles sizes. Worst-case conditions would be represented by an individual with 99th percentile inter-pupillary distance (IPD) wearing the small and the narrowest large goggles. The most recent male soldier data is from the 1966 survey (10) which gives this dimension as 2.80 inches. No comparable data could be found for females. As the female bicanthus dimension is slightly larger than the male, it must be assumed that IPD will also be larger. This increase will manifest itself as a slightly narrower field of view. No data could be found for the distance between the corneal plane and the glabella (the bony proturberance above the bridge of the nose between the eyebrows). Prescription lenses are usually placed 0.51 inches from the corneal plane (5). The glabella roughly coincides with the inside surface of such lenses. It seems reasonable to assume a stand off of 0.49 inches from the glabella to the goggles' lens giving a cornea-to-lens distance of 1.00 inches. In the large goggles, this distance will allow clearance for spectacles. This is an arbitrary reference point for this calculation and could readily change as the goggles' design evolves.

Figure 2 shows the calculated worst-case horizontal field of view for the two goggles.

The small goggles' calculated horizontal field of view was at least 62°, while the large goggles permitted at least a 112° field. If the standoff were reduced, or the lenses curved, the field would be widened.

SUMMARY

In response to the Army's need for improved protective goggles for combat-vehicle crewmen, HEL has developed design criteria for use by NARADCOM engineers. These criteria take into account physical characteristics of the soldier, as well as the modern equipment he uses in battle. Through evaluation of prototypes under simulated or actual use conditions and refinement of design, these new goggles should receive high soldier acceptability and usage.



Corneal /Lens Plane Distance 1.00"
99% Interpupillary Distance (2.80")

Figure 2. Horizontal field of view—worst case.

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